The Advantages of Using Distiller's Dried Grains with Solubles from Minnesota and South Dakota Ethanol Plants in Swine Diets

Dr. Jerry Shurson
Department of Animal Science
University of Minnesota

The overall goal of our research program has been to re-evaluate the nutritional value of distiller's dried grains with solubles (DDGS) in swine feeding programs. Historically, swine nutritionists have been reluctant to use significant quantities of DDGS in swine diets for a variety of reasons. This reluctance has been based upon nutritional and feeding information obtained 20 to 30 years ago. Since that time, many technological changes have occurred in the ethanol industry, and more precision is being used to formulate more nutritionally adequate swine diets. Based upon this information, nutritionists often consider DDGS to be highly variable in nutrient content within and among ethanol plants, have poor digestibility of amino acids, low energy relative to corn, questionable phosphorus availability, and may not be cost competitive relative to corn, soybean meal and dicalcium phosphate. These concerns are based on published nutrient composition and digestibility values in NRC (1998), Heartland Lysine Feed Ingredient Database, and Feedstuffs Reference Issue.

Through funding provided primarily by participating Minnesota and South Dakota ethanol plants, and support from the Minnesota Corn Growers Association, we conducted a series of experiments to determine if there is greater nutritional value of DDGS produced by new ethanol plants in Minnesota and South Dakota, compared to other industry sources, and compared to published nutrient content and digestibility values. As a result of demonstrating higher nutritional value of DDGS than previously shown, it would allow Minnesota and South Dakota DDGS to be differentiated in the market from other DDGS sources in the ethanol industry. In order to evaluate the nutritional value of DDGS for swine, a series of experiments were conducted to:

- Determine the nutrient content and digestibility of DDGS
- Determine the variability in nutrient content within participating plants
- Determine the impact of adding DDGS on manure management, gas, and odor emissions
- Determine the effects of formulating grow-finish diets on a total amino acid basis on growth performance, carcass characteristics, and pork quality
- Determine the economic value of DDGS in swine diets

Results

In general, results of these studies showed:

- DDGS from new ethanol plants in Minnesota and South Dakota have higher nutrient levels (Tables 1, 2, and 3), and higher energy (Tables 4 and 5), amino acid (Tables 6 and 7), and phosphorus digestibility compared to a common DDGS source in the ethanol industry and compared to published reference values.

- A linear regression analysis was conducted for P excreted and P retained relative to P intake for dicalcium phosphate and DDGS separately. The slope ratios of the regression lines from each phosphorus source were used to determine phosphorus availability. Availability of phosphorus in dicalcium phosphate was assumed to be 100%. Slopes for phosphorus excreted and retained were 0.354 and 0.646 (dicalcium phosphate, $r^2 = 0.42$ and 0.72) and 0.405 and 0.595 (DDGS, $r^2 = 0.55$ and 0.73), respectively. Availability of phosphorus, determined from the ratio of the slopes for DDGS and dicalcium, was 87.5% (excretion data) and 92.2% (retention data).

- Adding DDGS to grow-finish swine diets has no detrimental effect on ammonia, hydrogen sulfide or odor emissions from swine manure (Figures 1, 2, and 3).

- Adding DDGS to swine diets reduces the need for inorganic phosphorus supplementation, phytase supplementation, reduces diet cost, and significantly reduces phosphorus content in manure.

- DDGS can be added up to 20% of the diet for grow-finish pigs, if the diets are formulated on a total amino acid basis, without negative effects on growth performance (higher amounts can likely be used if diets are formulated on a digestible amino acid basis).

- Feeding diets containing DDGS to grow-finish pigs does not affect carcass muscle quality but can have an adverse effect on pork fat quality by increasing the amount of unsatuated fat and reducing fat firmness with increasing dietary inclusion rates (Table 8).

- Results from field studies studies suggest that adding 5 to 10% DDGS to grow-finish diets reduces mortality rates due to gut health problems (ileitis and gut edema). We are currently conducting controlled studies to further evaluate the effectiveness of DDGS on improving gut health of grow-finish pigs.

- DDGS can be effectively used as a partial replacement for corn, soybean meal and dicalcium phosphate and be an economical addition to practical swine diets.

- Adding 200 lbs of DDGS (and 3 lbs of limestone) to a finisher diet will replace:
  177 lbs of corn
  20 lbs of soybean meal 44%
  6 lbs of dicalcium phosphate

- Calculate the opportunity cost of using DDGS in swine diets as follows:

Additions:				
	+ DDGS	200 lbs	x	price/lb = $
	+ Limestone	3 lbs	x	price/lb = $
				Total A= $
Deletions:				
	- Corn	177 lbs	x	price/lb = $
	- Soybean meal 44%	20 lbs	x	price/lb = $
	- Dicalcium phosphate	6 lbs	x	price/lb = $
				Total D= $

Opportunity Cost:

Total D – Total A = Opportunity cost of DDGS/lb x 200 lbs/ton = Opportunity cost/ton of complete feed

- DDGS Can Be Effectively Used in Swine Diets With Dietary Inclusion Rates Ranging from 5 (Nursery Pigs) to 50% (Gestating Sows) of the Diet

Production phase	Feed Co-products Handbook (1997)	Pork Industry Handbook
Nursery	5%	5%
Growing pigs (18-55 kg)	7.5%	10%
Finishing pigs (55kg-mkt)	10%	10%
Gestating sows	50%	40%
Lactating sows	20%	10%

Table 4. Estimates of Digestible Energy (DE) and Metabolizable Energy (ME) of DDGS in Trial 1 (dry-matter basis).

	Control	10% DDGS	20% DDGS	30% DDGS	CV (%)
Grower					
GE intake (kcal/d)	3856 [a]	4024 [a,b]	3844 [a]	4263 [b]	6.51
DE intake (kcal/d)	3341	3556	3313	3586	6.38
ME intake (kcal/d)	3314	3533	3282	3554	6.45
DE intake/GE intake (%)	86.69 [a,b]	88.36 [a]	86.19 [b]	84.14 [c]	1.64
ME intake/GE intake (%)	86.02 [a,b]	87.80 [a]	85.37 [b,c]	83.39 [c]	1.93
DE DDGS*	----	5862 [a]	4478 [b]	4024 [b]	10.15
ME DDGS*	----	5827 [a]	4338 [b]	3957 [b]	10.43
Finisher					
GE intake (kcal/d)	6446 [a]	6720 [b]	6738 [b]	6829 [b]	3.00
DE intake (kcal/d)	5574	5970	5785	5783	6.03
ME intake (kcal/d)	5465	5912	5724	5663	6.38
DE intake/GE intake (%)	86.40	88.86	85.82	84.65	4.12
ME intake/GE intake (%)	84.70 [a,b]	87.99 [a]	84.89 [a,b]	82.90 [b]	4.50
DE DDGS*	----	5398 [a]	4153 [b]	3937 [b]	14.40
ME DDGS*	----	4820 [a]	3959 [b]	3794 [b]	14.69

a,b,c $P < .10$

* DE DDGS = (DE intake – (((1-% DDGS in diet)*ADFI) * DE control diet))/(% DDGS in trt diet *ADFI)

ME DDGS = (ME intake – (((1-% DDGS in diet)*ADFI) * ME control diet))/(% DDGS in trt diet*ADFI)

Table 5. Estimates of Digestible Energy (DE) and Metabolizable Energy (ME) of DDGS in Trial 2 (dry-matter basis).

	Control	10% DDGS	20% DDGS	30% DDGS	CV (%)
Grower					
GE intake (kcal/d)	4360	4309	4540	4661	0.00
DE intake (kcal/d)	3754 [a]	3705 [a]	3791 [a,b]	3872 [b]	2.31
ME intake (kcal/d)	3643 [a,b]	3578 [a]	3650 [a,b]	3736 [b]	2.78
DE intake/GE intake (%)	86.10 [a]	85.97 [a]	83.50 [a,b]	83.06 [b]	2.31
ME intake/GE intake (%)	83.56 [a]	83.02 [a,b]	80.40 [b]	80.16 [b]	2.79
DE DDGS*	----	2830	3314	3537	18.52
ME DDGS*	----	2551	3053	3347	24.83
Finisher					
GE intake (kcal/d)	7109	7175	7371	7543	0.00
DE intake (kcal/d)	3754 [a]	3950 [b]	3620 [c]	3872 [b]	2.75
ME intake (kcal/d)	3643 [a]	3824 [b]	3480 [c]	3736 [a,b]	2.95
DE intake/GE intake (%)	86.10 [a]	86.73 [a]	82.86 [b]	83.06 [b]	2.76
ME intake/GE intake (%)	83.56 [a]	83.94 [a]	79.64 [b]	80.16 [b]	2.97
DE DDGS*	----	3026 [a]	4090 [b]	3485 [a,b]	16.62
ME DDGS*	----	3010 [a]	3945 [b]	3328 [a,b]	16.79

a,b,c $P < .10$

* DE DDGS = (DE intake – (((1-% DDGS in diet)*ADFI) * DE control diet))/(% DDGS in trt diet *ADFI)

ME DDGS = (ME intake – (((1-% DDGS in diet)*ADFI) * ME control diet))/(% DDGS in trt diet*ADFI)

Table 6. Amino acid composition, apparent ileal and total tract digestible levels of MN DDGS and DDGS from an older Midwestern ethanol plant (OMP) (dry-matter basis).

	Amino Acid Composition		Apparent Ileal Digestible Amino Acid Levels		Total Tract Digestible Amino Acid Levels	
Amino Acid	**MNSD**	**OMP**	**MNSD**	**OMP**	**MNSD**	**OMP**
Arg, %	1.19 (4.2)	0.92	0.90 (6.0)	0.60 (8.00)	0.89 (12.6)	0.42 (17.4)
His, %	0.76 (4.3)	0.61	0.51 (5.6)	0.30 (9.4)	0.59 (3.7)	0.27 (16.1)
Ile, %	1.14 (6.0)	1.00	0.72 (10.3)	0.42 (15.5)	0.76 (7.8)	0.32 (36.2)
Leu, %	3.57 (3.1)	2.97	2.57 (6.8)	1.84 (6.9)	2.97 (4.7)	1.63 (12.3)
Lys, %	0.83 (10.1)	0.53	0.44 (12.7)	0.00 (380)	0.42 (11.8)	0.00 (87.1)
Met, %	0.55 (2.5)	0.50	0.32 (15.0)	0.24 (13.6)	0.32 (10.2)	0.15 (33.6)
Phe, %	1.48 (2.8)	1.27	0.89 (7.6)	0.68 (9.8)	1.11 (5.0)	0.60 (15.5)
Thr, %	1.13 (3.4)	0.98	0.62 (9.6)	0.36 (12.7)	0.74 (7.3)	0.32 (24.1)
Trp, %	0.24 (5.8)	0.19	0.15 (8.2)	0.15 (7.5)	0.19 (3.7)	0.14 (8.8)
Val, %	1.51 (3.7)	1.39	0.92 (9.9)	0.51 (14.7)	1.04 (6.4)	0.54 (23.6)

Note: Coefficient of variation shown in parenthesis

Table 7. Comparison of total and apparent digestible amino acid levels (dry-matter basis) between MN DDGS, older Midwestern plant (OMP) DDGS, NRC (1998), Heartland Lysine (1998), and Feedstuffs Reference Issue (1999).

	Total Amino Acid Levels					Apparent Digestible Amino Acid Levels				
Amino Acid	**MNSD**	**OMP**	**NRC 1998**	**HL 1998**	**FRI 1999**	**MNSD**	**OMP**	**NRC 1998**	**HL 1998**	**FRI 1999**
Arg, %	1.19	1.07	1.22	1.21	1.08	0.90	0.60	0.88	0.87	0.68
His, %	0.76	0.68	0.74	0.75	0.65	0.51	0.30	0.45	0.49	0.49
Ile, %	1.14	1.04	1.11	1.09	1.08	0.72	0.42	0.73	0.70	0.91
Leu, %	3.57	3.22	2.76	3.27	2.90	2.57	1.84	2.10	2.49	2.58
Lys, %	0.83	0.68	0.67	0.81	0.65	0.44	0.00	0.31	0.35	0.42
Met,%	0.55	0.49	0.54	0.63	0.65	0.32	0.24	0.39	0.45	0.55
Phe, %	1.48	1.30	1.44	1.43	1.29	0.89	0.68	1.09	1.09	1.14
Thr, %	1.13	0.99	1.01	1.11	1.02	0.62	0.36	0.56	0.60	0.73
Trp, %	0.24	0.22	0.27	0.20	0.22	0.15	0.15	0.14	0.10	n/a
Val, %	1.51	1.31	1.40	1.43	1.43	0.92	0.51	0.88	0.93	1.16

Figure 1. Effect of feeding a diet with or without 20% DDGS to grow-finish pigs on hydrogen sulfide emissions from manure.

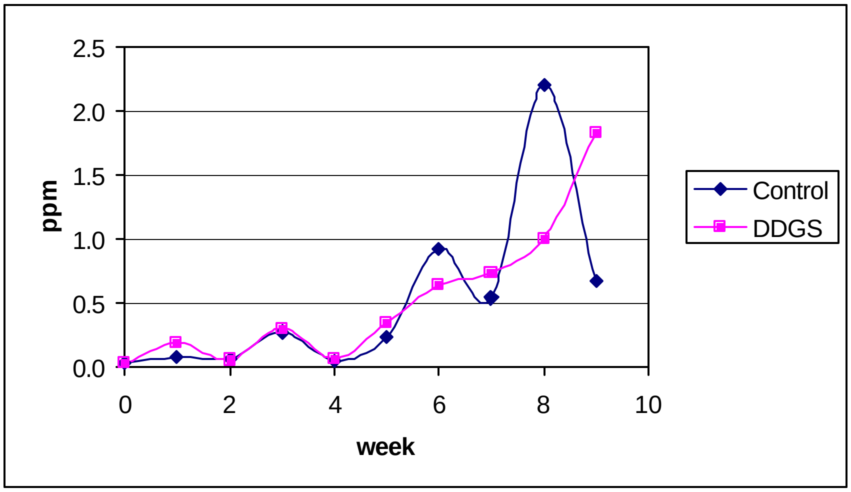

Figure 2. Effect of feeding a diet with or without 20% MN DDGS to grow-finish pigs on ammonia emissions from manure.

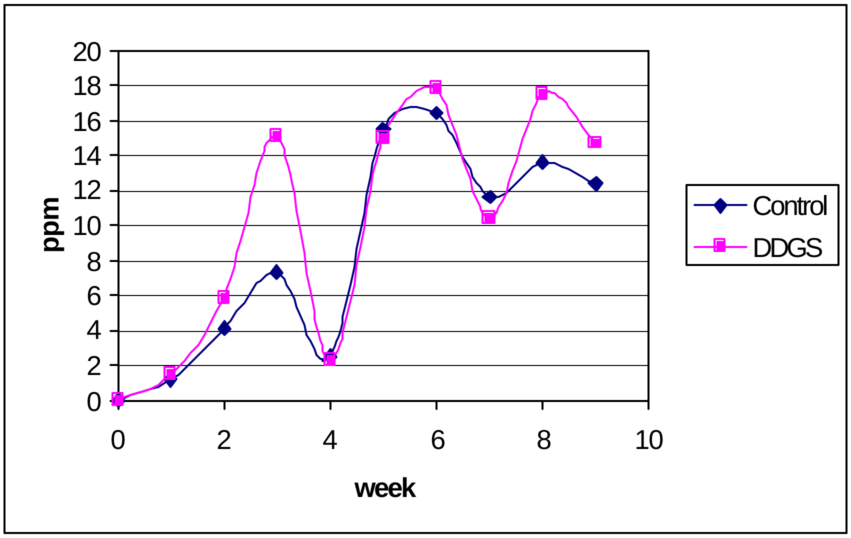

Figure 3. Effect of feeding a diet with or without 20% MN DDGS to grow-finish pigs on odor detection threshold from manure.

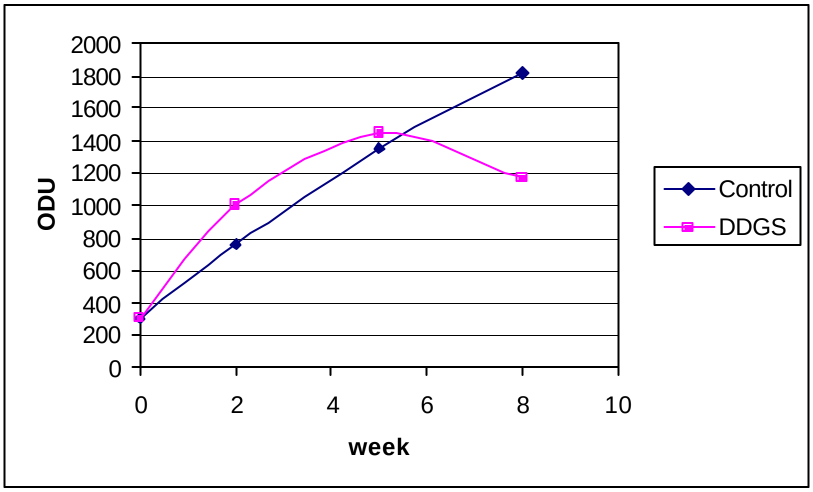

Table 8. Fat quality characteristics of swine fed differing levels of DDGS.

	Treatment				
	Control	***10%***	***20%***	***30%***	***RMSE***
Belly thickness, cm	3.15[c]	3.00[cd]	2.84[cd]	2.71[d]	0.56
Belly firmness score[a], degrees	27.3[c]	24.4[cd]	25.1[c]	21.3[d]	6.3
Adjusted belly firmness score[b], degrees	25.9[c]	23.8[cd]	25.4[c]	22.4[d]	5.4
Iodine number	66.8[c]	68.6[d]	70.6[e]	72.0[e]	3.4

[a]Belly firmness score = $\cos^{-1}[(0.5(L^2) - D^2)/(0.5(L^2))]$, where L = belly length measured on a flat surface and D = the distance between the two ends of a suspended belly; higher belly firmness scores indicate firmer bellies.

[b]Belly firmness score adjusted for belly thickness.

[c,d,e]Means within a row lacking a common superscript letter differ ($P < 0.05$).